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Operating Experience Summary

Office of Nuclear and Facility Safety

March 1 — March 10, 2000

Summary 2000-05

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Operating Experience Summary 2000-05
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1. BACKHOE OPERATOR CUTS BURIED ENERGIZED 480-VOLT CABLE

On March 1, 2000 Savannah River reported that on February 21, 2000, at Savannah River, a backhoe operator cut through an energized 480-volt underground cable during excavation of a new sanitary sewer line. The cut cable tripped a breaker and caused a near miss. Investigators found the tripped breaker, moved it to the off position, and locked it out until repairs could be completed. There were no injuries and, except for the cut cable, no other equipment was damaged. Contacting and cutting energized underground high voltage cables can cause serious injury. (ORPS Report SR--WSRC-CMD-2000-0004)

Investigators learned that the construction subcontractor was preparing a sewer tap for the radiological monitoring bioassay laboratory construction project. The backhoe operator snagged the 480-volt line while removing material during a hand-digging operation to locate identified interference. No workers were injured during the incident. Investigators determined that contractor personnel used ground penetrating radar to confirm marks installed by surveyors to locate known interferences within the buffer and excavation areas identified on drawings. Figure 1 shows the result of the ground penetrating radar survey. Known interferences are those reflected on the controlled record drawings. The buffer establishes the exploration limits where the ground penetrating radar is used to confirm known interferences and identify unmarked interferences.

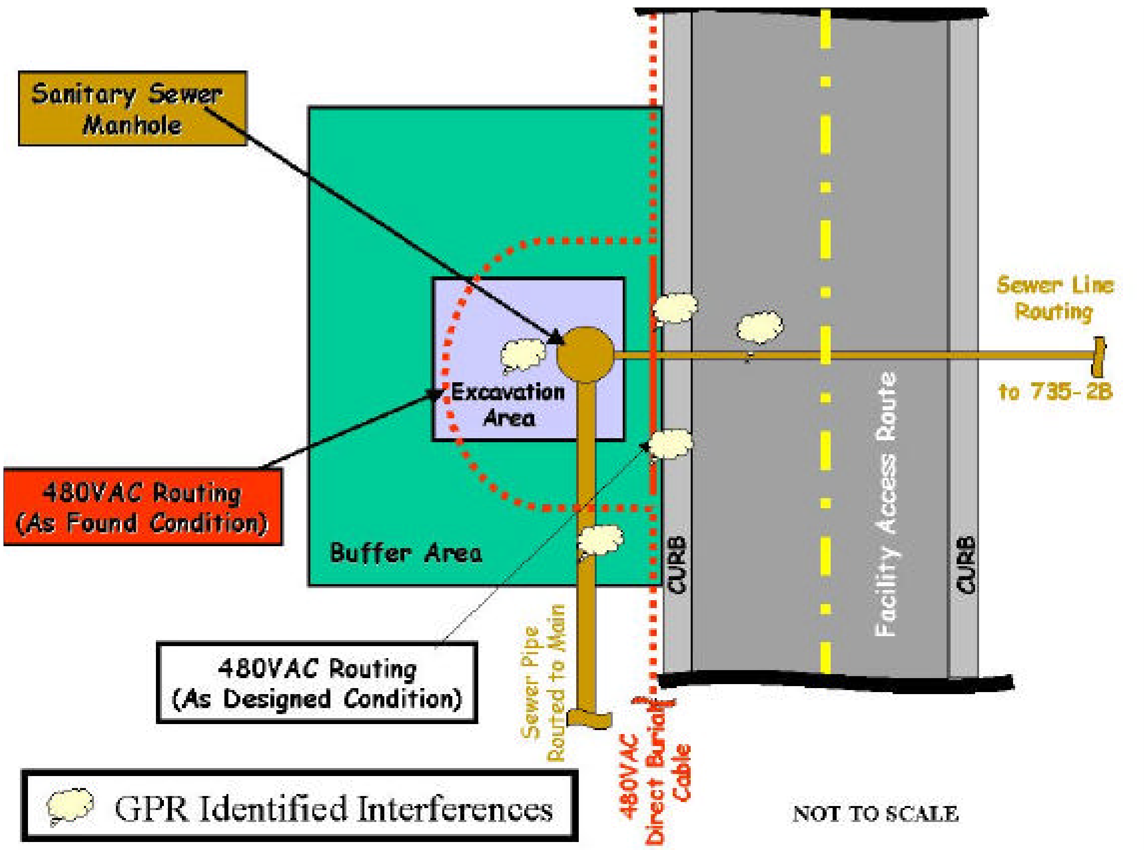

Figure 1-1 Location of re-routed cable

The ground penetrating radar indicated an interference paralleling the curb in the area located on the controlled drawings where the 480-volt electrical line was identified. Sewer lines were also noted both paralleling the road and perpendicular to the road. Another interference was confirmed beside the manhole within the excavation area limits. The contractor initiated hand digging to locate only the interference identified beside the manhole. The other interferences discovered didn’t conflict with his scope of work. The operator removed accumulated material from the excavation with a rubber tire backhoe until the excavation deepened to the point where the operator snagged the 480-volt line.

Local site utilities personnel, brought in after the cut cable was discovered, used a radio frequency signal to confirm the “as found condition” and the “as designed condition” shown on Figure 1-1.

The manhole in the drawing was installed during the original sewer project for the site. Four different subcontracts as well as the facility’s own work processes may have been responsible for laying and not recording the location of the subject cable. Investigators suggest a configuration management problem because of a previous cut in this 480-volt line several years ago when another sewer tap was made. The facility contractor apparently cut the cable and repaired the damaged cable by routing the new conductor around the manhole. The contractor apparently made no changes to the site drawings following this work. Excavation for the manhole and subsequent electrical installation excavation made it difficult to see the 480-volt line routed around the manhole, because ground penetrating radar could not see through the disturbed earth and barriers.

EH engineers identified the following similar events involving cutting buried electrical cables.

- Operating Experience Summary 99-05 reported that on January 20, 1999, at the West Valley Demonstration Project in the High Level Waste Tank Farm, a heavy equipment operator severed a 480-V extension cord when the bucket of the front-end loader that the operator was using to remove snow struck it. On January 1, 1999, workers had run the extension cord approximately 120 feet along the ground from an outdoor breaker box to an electric space heater. Several feet of snow fell and had to be removed to allow fork truck operation in the tank farm. The extension cord was not identified in the walk-down and was not discussed in the pre-job planning. (ORPS Report OH-WV-WVNS-HLLW-1999-0001)
- Operating Experience Summary 97-41 reported that on September 30, 1997, at a Los Alamos National Laboratory construction site, a subcontract backhoe operator pulled two de-energized 480-volt cables through a conduit with the teeth of the backhoe bucket and across an energized bus bar. The two cables pulled loose from their breaker connections inside a 480-volt switchgear and re-energized when the exposed copper cable ends contacted the incoming side of the energized bus bar. When the backhoe operator saw sparks, he immediately raised the bucket and moved the backhoe out of the area. Investigators determined that a communication error between the backhoe operator and a crew of electricians resulted in the incident. The backhoe operator incorrectly believed the electricians had already cut the cable to allow its removal. (ORPS Report ALO-LA-LANL-LANL-1997-0001)

KEYWORDS: electrical, cable, backhoe

FUNCTIONAL AREAS: Construction, Configuration Management, Industrial Safety

2. SITE PROCEDURE OVERLOOKED WHEN INCORRECT MATERIAL ADDED TO CHILLER SYSTEM

On February 25, 2000, at the Hanford Site, a subcontract worker failed to follow site procedure when he added hazardous ethylene glycol to the fuel retrieval system's new chiller. Site procedures specifiy using polypropylene glycol instead of ethylene glycol. The worker recognized his mistake and notified facility management who issued a change order directing the subcontractor to replace the ethylene glycol with polypropylene glycol as specified by site procedure. There were no injuries associated with this event. Failure to follow proper procedures can lead to injury or equipment damage. (ORPS Report RL--PHMC-SNF-2000-0004)

Investigators identified other recent events where the subcontractor failed to follow procedures, perform post maintenance, or apply quality assurance measures. On August 23, 1999, a work control representative reported that a wire rope inspection for a 24-ton crane had not been performed within the required surveillance period. The crane was used on three occasions after the August inspection date had passed. This event stemmed from failure to follow established procedures. (ORPS Report RL--PHMC-SNF-1999-0023)

On September 23, 1999, also at this facility, craft personnel failed to recognize potential load limits for basin grating while they moved an equipment cart containing rigging and a hydraulic drive unit weighing approximately 1,400 lbs. This event also stemmed from personnel not properly following established procedures (ORPS Report. RL-

PHMC-SNF-1999-0028). The similarity in corrective actions among many events at this facility seems to indicate that there may be a systemic, recurring procedure problem.

EH engineers identified the following similar event involving procedure problems.

- Operating Experience Summary 98-17 reported that on April 13, 1998, at the Rocky Flats Environmental Technology Plutonium and Processing Facility, an electrical arc occurred inside an enriched uranium decontamination activities glovebox because a process specialist failed to follow a procedure requiring power to be turned off. Investigators believe the arc occurred as the process specialist was lifting the lid for the decontamination fixture and it, or some of the material being processed, contacted energized electrodes in the glovebox. The specialist believed she received a shock because she felt heat and experienced a slight tingling in her arm. A qualified procedure verifier secured the power to the electrodes. An assisting radiation control technician instructed the specialist to sit down, checked the area for contamination, and notified the foreman. Medical personnel determined that no injury occurred and that the specialist was probably not shocked. The facility manager directed facility personnel to apply a lockout/tagout to the system to preserve the scene for further investigation. (ORPS Report RFO--KHLL-PUFAB-1998-0028)

KEYWORDS: procedures

FUNCTIONAL AREAS: Procedures, Management, Training and Qualification

3. CATASTROPHIC FAILURE OF PURGE AIR SILENCER

On February 23, 2000, at Savannah River, an audible alarm notification was received from the control room and a loud noise came from a breathing air system. Facility operator and technical engineering personnel discovered a catastrophic failure of the purge air outlet silencer on an air dryer vessel. Operations personnel secured the affected area and shut down the breathing air system. No one was injured, however the flying debris could have compromised safety of any personnel in the area. (ORPS Report SR--WSRC-LTA-2000-0004)

The dryer is a part of the breathing air purifier and consists of two desiccant-filled vessels (or towers). One vessel on line dries the incoming air going to the breathing system, while a non-heated air purge regenerates the second vessel. An electrically operated (solenoid) purge valve on the on-line vessel opens and reduces pressure at 5 minute intervals as a part of drying process. This causes shuttle valves to divert the incoming air to the opposite vessel. When the desiccant tower changes from the on-line to the purge position, the solenoid purge valve opens, allowing rapid venting of the stored air. This causes an air cannon effect with a sonic boom, resulting from a rush of air mass from the bottom of the tower. The muffler (or silencer) is mounted on the outlet of the purge valves to dampen the noise. It is designed to slow, disperse and dampen the air pressure impulse, which otherwise occurs when the air jet exits the pipe and undergoes a sudden expansion to atmosphere.

The failed silencer on the left in Figure 2-1, and the filter with pressure relief, Figure 2-2, are manufactured by Atomuffler. The silencer is a cylinderical device made from treated paper filter media rolled into layers with an outer metal protective shell. The desiccated air inside the unit escapes from the outlet side of the air dryer after passing through the muffling process. Investigators determined that the incoming air picked up desiccating dust, which tended to clog the filter media.

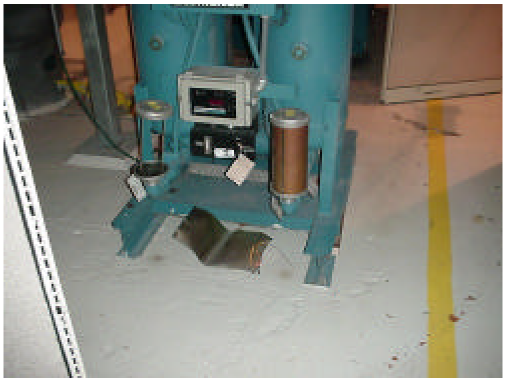

Figure 2-1.
Failed Silencer without Pressure Relief Valve

Figure 2-2.
Silencer with Spring-loaded Pressure Relief Valve

This restricted the flow of air, causing a backpressure on the on-coming purged air, resulting in an “air hammer” effect. The air hammer fatigued the filter media over time, and eventually caused it to fail. The investigators also determined that the failed device was lacking the following design features recommended by the manufacturer:

- Modified Filter Media- lining the inside of the muffler, to capture desiccant fines without significantly impeding the airflow.
- Orifice- provided at the inlet of the silencer, chokes the flow of air, limiting the magnitude of the air delivered and reducing “air hammer” effect.
- Pressure-actuated diversion valve or pressure relief valve, relieving static pressure above 13 psig.

These recommendations could have prevented a build up of excessive pressure in the breathing air system and consequent rupture of the filter media. Investigators discovered that another similar silencer equipped with a spring-loaded pressure relief device, Figure 2-2, performed its function without failure. Provision of a spring-loaded pressure-relief valve prevented air impulse damage on the muffler by diverting excess airflow. Investigators also determined that regular inspections and maintenance of the breathing air system would have helped line management to mitigate conditions contributing to the failure.

EH has reported a number of similar events involving near miss situations. The following are some examples.

- OE Summary 99-15 reported that on April 12, 1999, the health and safety manager for the Grand Junction Projects Office, Monticello Project, reported that a 1,000-gallon diesel fuel tank had suffered structural damage when it was over-pressurized during refueling. Because the fuel tank did not have adequate venting capacity, pressure built up, deforming the tank and launching the fuel nozzle approximately 15 feet into the air. As a result, 10 gallons of diesel fuel spilled, most of which remained inside a spill containment berm. The fuel vendor had supplied the diesel fuel tank and a 2,000-gallon gasoline tank to support Monticello project subcontractor operations. Improperly vented tanks can result in tank failure, release of tank contents, and personnel injury. (ORPS Report ALO--MCTC-GJPOTAR-1999-0001)
- OE Summary 98-23 reported that on November 6, 1997, at the Savannah River Technology Center Laboratory Technical Area, an in-line filter on a nitrogen system ruptured. Investigators determined that the filter failed because facility personnel used an incorrect design drawing when modifying the nitrogen test system and installed a low-pressure-rated (300 psi) filter on the high pressure (2,200 psi) side of a regulator. There were no injuries and only minimal equipment damage. This system can result in injuries or catastrophic damage to equipment. (ORPS Report SR--WSRC-LTA-1997-0032)

These events underscore the importance of proper design of components of operating systems and their timely preventive maintenance to ensure personnel safety. The following directives and standards provide guidance for developing design changes and system modifications of existing systems for improved and safer operations.

- DOE O 6430.1A, *General Design Criteria*, can be accessed from DOE Directives Home Page at http://www.explorer.doe.gov.
- DOE-STD-1073-93, *Guide for OperationalConfiguration Program* can be accessed at http://.tis.eh.doe.gov/techstds.

KEYWORDS: design deficiency, filter, muffler

FUNCTIONAL AREAS: Design Modifications, Preventive Maintenance

4. CRACKED WELDS ON ROUGH TERRAIN HYDRAULIC CRANES

On February 22, 2000, at Savannah River, maintenance workers conducting an annual inspection found weld cracks on the supports of the structure on a 90-ton crane. There were no injures and work was not stopped because the cracks were discovered before the crane was placed in service. The extent of the deficiencies is still being assessed as well as a decision whether to repair the damaged welds or scrap the crane. Weld cracks can pose a significant safety hazard to workers and structures. (ORPS Report SR--WSRC-CMD-2000-0003)

The crane is a Grove 90-Ton Rough Terrain Hydraulic Crane. It is one of four portable, heavy capacity cranes used for lifting at the Site. All four cranes, three 90-ton and one 80-ton, are 13 to 15 years old and are now cycling through annual inspections. The design life of these cranes is 10 years. Investigators determined that the cracked welds on the 15-year-old crane were identified during a load test portion of the inspection and cracked welds caused a deflection of the crane's boom. Investigators also found similar cracked welds during their inspections of the other three heavy capacity cranes, although none of those deficiencies caused a deflection of the crane boom during load testing. The cause of the cracked welds has not yet been determined, but investigators suspect that metal fatigue is a contributing factor.

The DOE-SR also owns a number of 22-ton and 40- to 45-ton rough terrain cranes. Investigators inspected a sampling of these smaller cranes, following the discovery of the weld cracks in the large cranes, and found no cracked welds. Most of these cranes are also manufactured by Grove Crane. All of the 40-to 45-ton rough terrain cranes are currently being inspected in connection with this problem. The cranes are generally the same age as the four 80-and 90-ton cranes, but have different configurations.

Local representatives of Grove Crane inspected the cracked welds on the subject crane and investigators expect that Grove factory representatives will also inspect the other cranes. Grove Crane had supplied inspection criteria for use in annual inspections, but these were not instrumental in identifying the cracked welds. The manufacturer has made suggestions for repairing the damaged welds, however, there has been no determination whether the damage is so severe that it is irreparable. If the initial inspected crane were to be scrapped and replaced the cost could range from $500,000 to $1 million.

Facility management plans to involve their quality assurance organization in resolving this problem. They have also contacted the DOE Hoisting and Rigging Topical Committee and the manufacturer, Grove Crane, to obtain information on incidence of cracked welds on similar pieces of equipment. Facility management stated that a sound engineering basis will be employed should the cracked welds be repaired and the crane returned to service.

Facility managers, maintenance, and quality assurance personnel should review the following references, which provide guidance and good practices applicable to the current issue (i.e., Quality Assurance, testing, surveillance).

DOE-STD-1090-99, *Hoisting and Rigging*, provides guidance for hoisting and rigging and identifies related codes, standards, and regulations. It is available on the DOE Technical Standards Home Page, http://tis.eh.doe.gov/techstds

American Society of Mechanical Engineers ASME Standard B-30.5-1994, applies to the construction, installation, operation, inspection, and maintenance of jacks; power-operated cranes, monorails, and crane runways; power-operated and manually-operated derricks and hoists; lifting devices, hooks, and slings; and cableways. ASME B 30.5-1994, along with specific Grove Crane criteria, provides the primary basis for the annual inspection where the cracked welds were identified.

KEYWORDS: rough terrain crane, cracked welds

FUNCTIONAL AREAS: Construction, Maintenance, Industrial Safety

5. VENTILATION FAN DISINTEGRATES

On February 18, 2000, at a Los Alamos National Laboratory administrative building a 36-inch office heating and ventilating fan malfunctioned and came apart, scattering debris in the fan room. A maintenance worker discovered the broken fan after office workers complained of warm offices. Temporary ventilation was used to supply air to the offices. There was no impact to health and safety of personnel; however, any person near the fan could have been seriously injured. (ORPS Report ALO-LA-LANL-ADOADMIN-2000-0001)

Investigators determined that the fan supplies air to various offices in an administration building and that it had malfunctioned during the night. Pieces of the fan wheel were scattered around the fan room. Investigators determined that the end wheel of a multiple wheel squirrel cage belt-driven fan had rotated off its shaft, contacted the housing, and broke in pieces. The investigators also found that the housing had dislodged from its mountings and was resting on the fan drive shaft. They also determined that the fan motor had tripped on over-current due to friction caused by the dislodged fan-housing rubbing on the fan shaft. At this point in the investigation the cause of the dislodged fan housing is unknown. The fan and motor assembly are over 43 years old and the estimated cost to replace them is approximately $10,000.

Investigators determined that during maintenance on the fan, a bearing had been replaced because of vibration. Investigators have also determined that a design change had been applied to the unit, which raised the airflow. The increased airflow was below the system high limit setting and was verified as safe. Investigators determined that there was no visible vibration associated with this higher flow. The unit was hard anchored and no vibration isolators were used on the fan-housing portion of the unit.

KEYWORDS: bearing, HVAC fans, maintenance

FUNCTIONAL AREAS: Mechanical, Malfunction

6. LEAD ACID BATTERY EXPLODES DURING CRANE INSPECTION

On February 23, 2000, at Savannah River, a 12-volt lead acid battery exploded when a crane operator turned on the crane's ignition as part of a periodic inspection. The crane's battery box completely contained the explosion, and there were no injuries sustained as a result of the incident. Facility management held a critique of the event, posted an alert concerning proper battery maintenance, and returned the battery to the manufacturer to investigate the cause of the explosion. Malfunctioning lead acid batteries can produce highly volatile hydrogen gas that can explode and cause serious injury to personnel or damage to equipment. (ORPS Report SR--WSRC-CSWE-2000-0004)

Investigators determined that the 22-ton rough terrain crane uses two lead acid batteries in series. One battery is maintenance-free while the battery that exploded is the type that requires periodic maintenance. Investigators speculated that the incident occurred when water in one of the battery's cells underwent electrolysis. Investigators determined that when the water in a cell drops below the top of the cell's conductor, electrolysis can take place and produce hydrogen. They also determined that electrolysis occurs when the charging voltage exceeds 2.4 volts per cell. Investigators determined that the battery did not have identification labels or adequate maintenance records, making it difficult to trace the battery's history. Investigators belive that the potential ignition source was a spark from a poor battery terminal connection. Investigators are waiting for the battery manufacturer's test report and will provide those results when they become available.

As part of the on-site lessons learned program, facility management developed the following key points for personnel who work with and maintain lead acid batteries.

- If a battery is housed in a protective box personnel should ensure that the box and lid are intact and well vented before use.
- Personnel should follow prescribed safety procedures any time a battery is charged or jump-started.
- Personnel should avoid introducing ignition sources in the vicinity of batteries that are operating or being charged.
- Personnel should check terminals for corrosion or loose connections.
- While the operation, charging and discharging of lead-acid batteries does not normally produce explosive gases, overcharging a battery transforms it into an electrolysis machine that uses electric current to convert water into hydrogen and oxygen. On maintenance-type batteries these gases are released through baffles in the cell caps. The caps are designed to dilute and vent the gases to the surrounding atmosphere while preventing an external ignition source from backfiring into the battery cell. On maintenance-free batteries these gases are gradually recombined into water.
- A charging voltage of about 2.4 volts or greater across any single cell is enough to produce explosive gases. When the electrolyte bubbles, that is an indication that water is being converted into explosive hydrogen and oxygen. It is important that personnel set the voltage of a battery charging system within the prescribed specifications.
- The electrolyte in lead acid batteries is diluted sulfuric acid. Sulfuric acid is not consumed in normal battery operation, however in a maintenance-type battery water can evaporate or be electrolyzed. If the electrolyte level falls low enough to expose the battery's lead plates they can become permanently sulfated and shorten the battery’s life. Low electrolyte levels can also expose potential electrical faults within a battery cell and generate a spark that could ignite explosive gases inside the cell.
- Personnel should check electrolyte levels when servicing a maintenance-type battery and replace lost water.
- To avoid confusion, personnel should not place maintenance-type and maintenance-free batteries in the same battery compartment or use them on the same piece of equipment.

EH engineers identified the following similar event involving lead acid batteries.

- Operating Experience Summary 99-12 reported that on March 8, 1999, at the Idaho National Engineering Environmental Laboratory Central Facilities Area, a utility operator was starting a diesel-driven fire water pump for a weekly test run when one of the associated batteries exploded. He was approximately 20 feet away when the battery exploded and spilled approximately 1 quart of acid on the concrete floor. The operator was not injured, so he secured the evolution and notified the appropriate supervisor of the explosion. A protective plastic covering over the battery bank was damaged when the battery exploded. No one had performed any inspection or surveillance of the facility firewater batteries. (ORPS Report ID--LITC-CFA-1999-0003)

Facility managers should ensure that personnel are properly trained in the use and maintenance of lead acid batteries. The following reference may provide further insight on this subject.

DOE-HDBK-1084-95, *Primer on Lead-Acid Storage Batteries*, provides information on the operation, construction, and maintenance of lead-acid batteries. The handbook also provides information on the hazards associated with storage batteries and recommended precautions. Information on battery chargers and charging operations is provided in the maintenance section. It is available on the DOE Technical Standards Home Page, http://tis.eh.doe.gov/techstds

KEYWORDS: battery explosion, battery charging, electrolysis

FUNCTIONAL AREAS: Industrial Safety, Electrical, Maintenance

7. CUTTING TORCH SPARKS CAUSE LEAKING PROPANE BOTTLES TO IGNITE

On February 17, 2000, at Oak Ridge National Laboratory, two workers were torch-cutting piping in an overhead area when slag and sparks fell and ignited a leaking 40-pound propane tank on the floor beneath them. Fire watches extinguished the flame, instructed the two workers to stop work, and notified facility management. Facility management notified the propane bottle vendor about the leaking bottles. There were no injuries and no equipment damage associated with this event. Leaking propane bottles can ignite or explode when stored or used in the vicinity of torch-cutting activities, and slag or sparks from torch cutting operations can act as an ignition source for a fire or explosion in the presence of combustable. (ORPS No. ORO-DRS-ETTP1420-2000-0002)

Investigators determined that the fire ignited at points where the propane supply line and pressure gauge connect to the propane bottle and that the facility had six other propane bottles exhibiting similar leaks. They determined that the bottle vendor performs quality assurance inspections on all bottles before they are shipped and that facility management did not perform a receipt inspection. Investigators determined that facility management now requires a visual inspection of all gas bottles before they are stored or used.

EH engineers identified the following similar events involving leaking propane tanks.

- Operating Experience Summary 99-12 reported that on March 15, 1999, at the Oak Ridge East Tennessee Technology Park, Property and Materials Management personnel reported to facility supervision that a 150-lb propane cylinder was leaking in a covered but open storage shed. Site protective forces blocked the streets around the storage shed, all personnel in the area were evacuated, and the site fire department responded to the scene. A hazardous materials response team stopped the leak, using leak-patching equipment to seal the cylinder valve and valve cap. After the leak was stopped, the cylinder was moved to a safe location. (ORPS Report ORO--BJC-K25GENLAN-1999-0005)

The requirements of 29 CFR 1910.101, "Compressed Gases," state that the in-plant handling, storage, and use of compressed gases in cylinders shall comply with Compressed Gas Association Pamphlet CGA P-1, *Safe Handling of Compressed Gases*. Pamphlet CGA P-1 costs $78.00 for nonmembers of the Compressed Gas Association. (703) 412-0900, extension 799, between 0900 and 1630 EST.

KEYWORDS: propane bottle, compressed gas, fire watch, torch cutting, leak

FUNCTIONAL AREAS: Work Planning, Industrial Safety, Material Handling/Storage

FOLLOWUP ACTIVITY

1. MULTIPLE INJURY ACCIDENT UPDATE FROM A SODIUM-POTASSIUM EXPLOSION

Operating Experience Summary 99-48 reported that 11 workers were injured on December 8, 1999, at the Oak Ridge Y-12 Plant during a Sodium-Potassium (NaK) explosion at Building 9201-5. Three workers were hospitalized; one was in critical condition with third-degree burns on 17 percent of his body. The worker received a number of skin grafts before leaving the hospital on December 21, 1999. This accident highlighted deficiencies in numerous aspects of safety management at the Y-12 Plant.

On December 1, 1999, Depleted Uranium Operations (DUO) workers in Building 9201-5 were changing out the crucible in the skull caster furnace. The workers were using a new procedure for the activity. When workers removed a flexible argon purge hose from the crucible, several gallons of NaK sprayed out through an open isolation valve into the furnace. Over the next several days, the workers monitored conditions in Building 9201-5 and intermittently purged the furnace with argon in an attempt to minimize further oxidation. Facility management developed a recovery plan outlining the process for cleaning up the NaK spill. On Friday, December 3, the workers observed unusual and unexpected conditions in the furnace, including a yellow color and abnormal configuration of the material. Mineral oil was sprayed on the deposits to minimize oxidation.

On December 8, the explosion occurred while the workers were attempting to clean up the NaK using a vacuum probe and metal rod, having sprayed additional mineral oil. The direct cause of the explosion was the impact of a metal tool on a shock-sensitive mixture of potassium superoxide (KO_2) and mineral oil. The December 1 NaK spill resulted from numerous deficiencies in the new procedure for crucible changeout. During this work activity, the workers made pen and ink changes without stopping to obtain proper review and approval of the changes. A key step requiring opening the dump valve to drain the crucible NaK piping had been inadvertently deleted from the procedure, resulting in a failure to open the valve to trap the remaining NaK under argon pressure. When workers observed an unexpected NaK level in the sump, they did not stop to analyze the system configuration or seek assistance before repeating parts of the procedure. A worker climbed into the furnace to disconnect the argon purge hose. When the hose was disconnected, the trapped NaK sprayed out under pressure into the furnace through an open isolation valve that was also incorrectly aligned because of procedural deficiencies.

The Office of Oversight issued a Type A Investigation Board Report on the accident in February 2000. The report identified six root causes.

- LMES failed to establish, seek, or maintain an adequate level of knowledge and competence on the hazards associated with NaK, including the formation of superoxide, the incompatibility of superoxide and organics, and the explosive sensitivity of the mixture to impact or shock.
- LMES's hazard analysis and control processes failed to identify, prevent, or mitigate the explosive interaction of potassium superoxide, mineral oil, and impact. The NaK Material Safety Data Sheet was not used.
- LMES management systems and processes did not assure adequate procedures or controls to prevent the loss of system configuration control resulting in an NaK spill or to preclude the addition of mineral oil and impact in the presence of potassium superoxide during NaK spill recovery.
- LMES management failed to effectively communicate or utilize information from the hazard screening evaluation, lessons learned, previous events and accidents, studies, analyses, and publications in planning and controlling this work and the associated hazards to worker health and safety. Knowledge of this hazard and expertise to address it were readily available at the Oak Ridge Reservation and other DOE sites.
- Oak Ridge, Y-12 Safety Operations, and Lockheed Martin Energy Systems have not established or assured a safety culture that implements an Integrated Safety Management process in which workers are consistently held accountable for adherence to procedures and hazard controls and are willing to stop work and seek management and technical assistance when procedures do not work or abnormal conditions are encountered.
- LMES management systems and processes were not effective in assuring the provisions for and use of appropriate personal protective equipment for working with a pyrophoric liquid metal and protecting against thermal and caustic chemical burns and the inhalation of toxic and radioactive smoke.

The Investigation Board cited several needed improvements, a few of which follow:

- Strengthening the implementation of ISM core functions and existing LMES processes to assure that all potentially hazardous work and activities are subjected to effective, formal, and documented hazard analysis.
- Strengthening the identification and implementation of engineering, administrative, and worker protection controls for potentially hazardous work and activities.
- Improving the identification, availability, and use of appropriate personal protective equipment to protect workers against work-related hazards.

The full report can be found at http://www.eh.doe.gov/oversight/acc_inv/y-12_report/.

KEYWORDS: injury, chemical, procedures, sodium, potassium

FUNCTIONAL AREAS: Explosion, Personnel Injury, Work Activity